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**PREFERRED LISTENING RATE AS A FUNCTION
OF EXPOSURE TO TIME-COMPRESSED
SPEECH AND TYPE OF TIME-COMPRESSION**

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U. S. Army

Research Institute for the Behavioral and Social Sciences

June 1982

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compressed speech rates were comparable to other preferred listening rate values reported in the literature. The gain in rates was discussed in terms of learning, habituation, and type of information processing.

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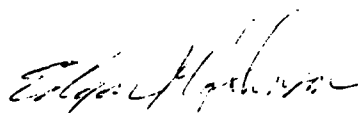
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FOREWORD

Within the U.S. Army Research Institute for the Behavioral and Social Sciences (ARI), research on perception and cognition has been conducted by the Human Factors Technical Area. Previous research reports have dealt with processing of auditory information at rapid rates. Technical Paper 295 discussed comprehension of time-compressed speech as a function of training. Technical Papers 296 and 297 presented a method for measuring the maximum rate of speech understood by individual listeners through repeated judgments of comprehensibility. This report deals with changes in the preferred listening rate immediately after the introduction of time-compressed speech.

This work was done under Army Project 2T161101A91B, and its results are applicable to a wide range of voice communication situations in the Army and, in fact, in any situation in which the choice of listening rate is under control of the listener.



EDGAR M. JOHNSON
Technical Director

PREFERRED LISTENING RATE AS A FUNCTION OF
EXPOSURE TO TIME-COMPRESSED SPEECH AND TYPE OF TIME-COMPRESSSION

EXECUTIVE SUMMARY

Requirement:

Speech technology has made it possible to reproduce speech at rates far beyond man's capacity to understand it. The purpose of this work is to obtain information about the preferred rate of listening, which may be equally as important as information about the maximum rate of speech which can be understood.

Procedure:

A method was developed for presenting two types of time-compressed speech, the rate of which could be controlled by the listener. Provision was made for recording the rate of speech. The preferred rate was determined immediately after presentation for each of two types of time-compressed speech. After an exposure of approximately one hour, preferred rates were again determined.

Findings:

The preferred rates at initial exposure were near the normal speaking rate. After exposure the rates rose for both types of speech. The rise was relatively greater for compressed speech than for speeded speech, the compressed speech rate being in the range usually reported in the literature. Results may have implications for the type of information processing taking place.

Utilization of Findings:

The fact that the rate changes rapidly soon after the initial exposure suggests that investigations of preferred listening rates should specify the amount of prior exposure.

PREFERRED LISTENING RATE AS A FUNCTION OF
EXPOSURE TO TIME-COMPRESSED SPEECH AND TYPE OF TIME-COMPRESSSION

INTRODUCTION

Although listeners can comprehend speech at approximately twice the normal rate, they do not usually choose to do so. From a practical point of view, the preferred listening rate may be more important than the rate at which listeners can understand speech.

The process of speech time-compression enables investigators to determine the preferred listening rate conveniently and without regard for the maximum rate of human speech production. The most straightforward method of time-compressing speech is to increase the rate of recorded speech over the rate at which it was originally recorded (usually called speeded speech). Although the word rate is increased by this process, the pitch of the speech is increased in proportion to the increase in speed.

The sampling method of speech time-compression repeatedly samples the speech signal and discards a portion of each sample. The sampling rate is very high, but the discarded portions are very brief. This results in time-compressed speech without an increase in pitch (usually called compressed speech). Garvey (1955), who devised the sampling method, reported that word intelligibility of compressed speech was higher than that of speeded speech. Using a perceptual threshold method, de Haan (1977) reported similar findings for connected, free-running speech. In summary, the sampling method (compressed speech) yields time-compressed speech of higher intelligibility than the speed-changing method (speeded speech).

A number of investigations of preferred listening rate using compressed speech has yielded a fairly broad range of values, from 163 to 225 words per minute (wpm). Hutton (1955), for example, in a psychophysical study of perception of the rate of speech (using relatively brief materials ranging from 8.0 to 42.6 secs in duration), found that the most preferred rate for adult listeners was 163 wpm. Foulke and Sticht (1966) allowed college students to manipulate the rate of speech passages of moderate difficulty and found the mean preferred listening rate to be 207 wpm. Interestingly, Foulke (1965) found the preferred rate of blind listeners to be much higher than that of sighted persons, approximately 275 wpm.

Lass and Cain (1972) measured both reading rates and preferred listening rates. They reported that the mean preferred listening rate was 183 wpm and that there was a correlation of .61 between preferred listening rate and reading rate. Lass and Prater (1973) compared listening rate preferences for reading passages and impromptu speech passages. Preferred listening rates were comparable for the two types of listening material, the most preferred rate being 175 wpm and the least preferred 100 wpm.

Cain and Lass (1974), using a paired comparison method to present passages between 100 and 350 wpm, found that the most preferred listening rate was 175 wpm. Lass, Foulke, Nester, and Comerici (1974) investigated the effects of listening to increasingly more rapid compressed speech, over a period of six weeks, on both preferred listening rate and comprehension. They reported that although such training did not improve comprehension skills, it did increase preferred listening rate. The most preferred rate (paired comparison method) after training was 225 wpm.

Lass and Leeper (1977) compared preferred listening rates with two types of speech compressors, one of which used the sampling technique (the Vari-speech I), while the other used a technique which shortened pauses and vowels (the VOCOM). The most preferred rate was reported to be 225 wpm with the Vari-speech and 200 wpm with the VOCOM.

Gade and Gertman (1979) reported that, although individuals can be induced by instructions and prior listening experience to listen to speech at rates well above their preferred rates, preferred rates were not modified by brief listening experiences. The mean preferred rate was 142% of normal rate in this work (approximately 179 wpm).

The purpose of the present work was the empirical investigation of the effects of exposure to time-compressed speech and type of time-compression on preferred listening rate.

EXPERIMENT I

The purpose of this experiment was simply to determine the effect of two types of speech time-compression on the preferred listening rates of naive listeners at initial exposure. In order to accomplish this, listeners were presented with two types of time-compressed, connected, free-running speech, reportedly different in intelligibility: speeded speech and compressed speech. Their preferred listening rates were determined immediately after introduction to each type of speech.

Method

Participants. Twenty-eight enlisted personnel, 21 males and 7 females, participated in this research. They had general ability scores of at least 110 on the General Technical Scale of the Army Classification Battery at the time of enlistment. (The mean of this scale is 100 and the standard deviation is 20.) None of them had known hearing defects or experience with compressed speech.

Stimulus Materials. The stimulus materials were tape recordings of passages from a book of historical portraits, The Proud Tower (Tuchman, 1966), recorded at the Library of Congress, Division for the Blind and Physically Handicapped. The passages were read by a female voice at an average word rate of 126 wpm and are described more fully elsewhere (de Haan, 1977).

Apparatus. A Crown (800 series) variable-speed tape recorder was used to reproduce speech and, together with a speed-control device (Crown VSD-5), produced time-compressed speech by the speed-changing method. An AmbiChron speech compressor (Koch, 1974) was used in conjunction with the above equipment to produce time-compressed speech by the sampling method. Speech was delivered binaurally through headphones (Telephonics, TDH-39). Listener controls included one knob to regulate intensity and another to regulate rate of speech by means of a 10-turn potentiometer. Additional details of the apparatus can be found in earlier reports (de Haan, 1977; de Haan & Schjelderup, 1978).

Experimental Design and Procedure. The independent variable was type of time-compressed speech, speeded (speed-changing method) or compressed (sampling method). Each listener was instructed to set the intensity of speech at a comfortable listening level and then was allowed to listen to either speeded or compressed speech while the experimenter turned the control knob to adjust the rate of speech through a range of approximately .5 to 3.0 times the normal rate. This took approximately one to two minutes. The listener was then instructed to set the rate of speech at the rate to which he or she would prefer to listen by adjusting the rate control knob. Since the interest was in the initial exposure, there were only two trials, one for each type of time-compressed speech. Half of the listeners received speeded speech first; the other half, compressed speech first.

Results

Table 1 shows the mean preferred listening rates for speeded and compressed speech. The mean rate for speeded speech, approximately 140 wpm, was below that for compressed speech, approximately 148 wpm. Although the mean difference was only 7.57 wpm, it was significant when tested by a t test for correlated means, $t = 2.054$, $p < .05$. In fact, rates for both speeded and compressed speech were near the normal speaking rate. They are also below the values of preferred listening rates cited in the literature.

Table 1
Preferred Listening Rates for Two Types of Time-Compressed Speech
in Words per Minute
(N = 28)

| Type of Speech | Mean | SD | Difference |
|----------------|--------|-------|------------|
| Speeded | 139.98 | 15.62 | 7.57* |
| Compressed | 147.55 | 18.40 | |

* $p < .05$

EXPERIMENT 2

It was noted in the previous experiment that the preferred listening rates were both below the range of values for compressed speech cited in the literature, from 163 to 225 wpm. Lass et al. (1974) demonstrated that repeated exposures to time-compressed speech will raise the preferred listening rate. It was therefore decided to investigate the effect of additional exposure to time-compressed speech on the preferred listening rates.

Method

Participants. Twenty-eight military enlisted personnel participated in the research. They had general ability scores of at least 100 on the General Technical Scale of the Army Classification Battery at the time of enlistment. (The mean of this scale is 100 and the standard deviation is 20.) There were 18 males and 10 females. None of the participants had previous experience with time-compressed speech or any known hearing defect.

Stimulus Materials and Apparatus. The stimulus materials and apparatus were the same as those used in Experiment 1.

Experimental Design and Procedure. Each listener was presented with connected, free-running speech through earphones and was instructed to adjust the volume to a comfortable listening level. The experimenter manipulated a 10-turn potentiometer knob on the listener's control box to present speech in a range of rates from approximately .05 to 3.0 times the normal rate. Listeners were then instructed to set the rate control at the rate to which they would prefer to listen. Both speeded and compressed speech were presented to each listener, half the listeners receiving speeded speech first and half receiving compressed speech first. Two trials were presented for each type of speech and were averaged to give pre-experimental listening rate for each type of speech.

Following the determination of the pre-exposure listening rates, listeners participated in other experiments with time-compressed speech lasting approximately an hour. During this time, they were exposed to both speeded and compressed speech for equivalent amounts of time. Immediately afterwards, their preferred listening rates were obtained once more with each type of speech, in the same order described above. The latter constitutes the post-exposure preferred listening rate. The experimental design was a factorial design which included three within-subjects factors: type of speech, exposure to time-compressed speech, and within-session trials. Order of speech presentation (speeded or compressed first) was a between-subjects factor.

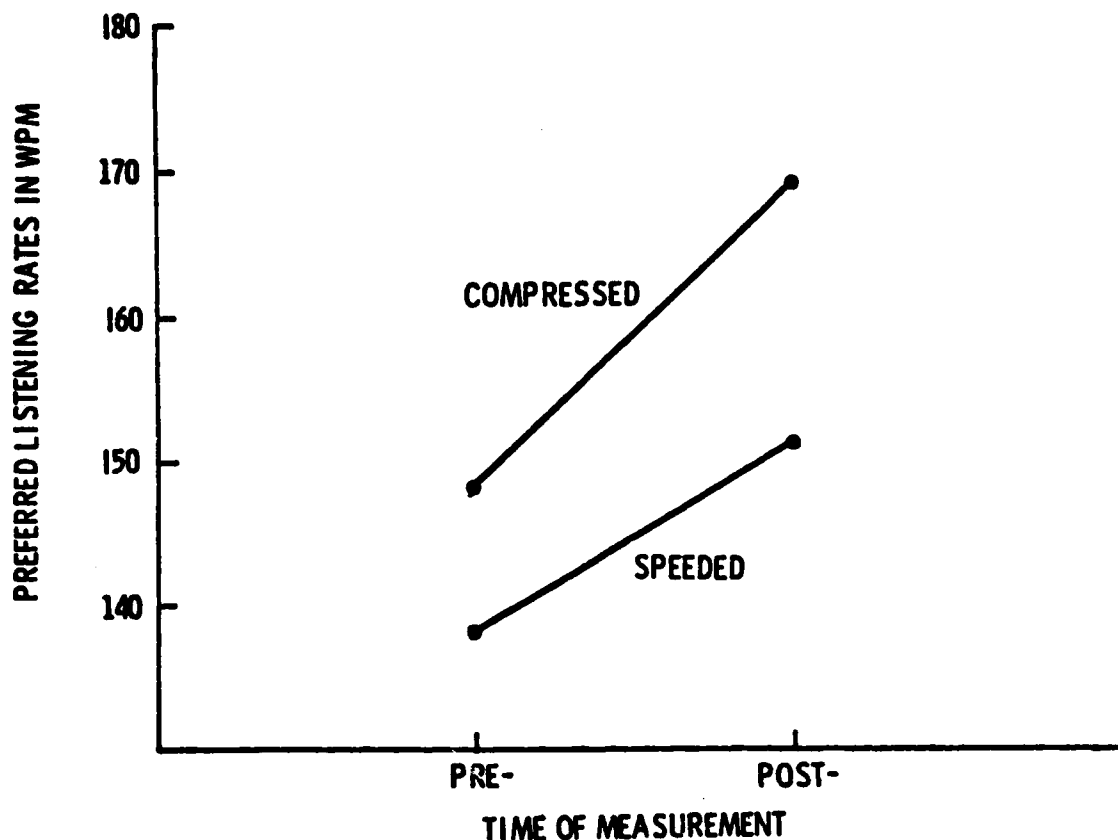


Figure 1. Pre- and post-exposure preferred listening rates in words per minute (Experiment 2).

Results

Figure 1 and Table 2 show pre- and post-exposure listening rates for each type of time-compressed speech in wpm. The magnitudes of the pre-exposure means, approximately 138 and 148 wpm for speeded and compressed speech, respectively, were very similar to the magnitudes of the means in Experiment 1. The magnitudes of the post-exposure means rose to approximately 151 wpm for speeded speech and 169 wpm for compressed speech. The data were analyzed by an analysis of variance and the results are shown in Table 3. The post-exposure gain was significant $F(1,26) = 39.49$, $p < .01$. The difference between speeded and compressed speech was also significant $F(1,26) = 90.15$, $p < .01$ as was the interaction of speech-type and exposure $F(1,26) = 8.40$, $p < .01$. The within-session trials effect was also significant $F(1,26) = 4.85$, $p < .05$. Order of presentation of speech-type was not significant $F(1,26) = .370$, $p > .05$. In summary, exposure to time-compressed speech increased the preferred listening rates for both speeded and compressed speech and the increase was relatively greater for compressed than for speeded speech.

Table 2

Pre- and Post-Exposure Preferred Listening Rates for Two Types
of Time-Compressed Speech in Words per Minute
(N = 28)

| Type of Speech | Pre-Exposure | | Post-Exposure | |
|-------------------|--------------|-------|---------------|-------|
| | Mean | SD | Mean | SD |
| Speeded | 138.29 | 11.48 | 150.71 | 18.99 |
| Compressed | 147.53 | 16.57 | 168.86 | 23.02 |

Table 3

Summary of the Analysis of Variance of
Preferred Listening Rate Data

| Source | SS | DF | MS | F |
|--------------------------------|----------|----|---------|---------|
| Between Subjects | 1.598398 | | | |
| Groups (G) | 0.022261 | 1 | .022261 | 0.37 |
| SswG(e ₁) | 1.576137 | 26 | .060207 | |
| Within Subjects | 1.474158 | | | |
| Speech Type (S) | 0.331035 | 1 | .331035 | 90.15** |
| Trials (T) | 0.017826 | 1 | .017826 | 4.85* |
| Sx(SswG) (e ₂) | 0.095478 | 26 | .003672 | |
| Exposure (E) | 0.501830 | 1 | .501830 | 39.49** |
| E x G | 0.040167 | 1 | .040167 | 3.16 |
| E x (SswG) (e ₃) | 0.330414 | 26 | .012708 | |
| E x S | 0.034968 | 1 | .034968 | 8.40** |
| E x T | 0.014153 | 1 | .014153 | 3.40 |
| E x Sx(SswG) (e ₄) | 0.108288 | 26 | .004165 | |

*p < .05

**p < .01

DISCUSSION

In both experiments, type of speech time-compression had an effect on preferred listening rates, the means for compressed speech being higher than those for speeded speech. This suggests that the present findings may be due to speech intelligibility, since it is well established that the higher-pitched, speeded speech has lower intelligibility than pitch-normalized, compressed speech. On the other hand, the pitch of speeded speech might have affected the preferred listening rate directly.

Before experience with compressed speech, listeners chose rates which were close to the normal speaking rate. Upon exposure to time-compressed speech, there was a fairly rapid rise in preferred rates. After only an hour of exposure, the rate for the more intelligible compressed speech rose to 169 words per minute. This is in the range of rates cited in the research literature, extending from 163 to 225 wpm. This rather broad range may be the result of different durations of exposure. The value of 275 wpm cited by Foulke (1965) for blind listeners could well represent a case where the gap between typical behavior and capacity is closed by high motivation and might indicate potential performance levels for sighted persons.

In the second experiment, since the initial preferred rate rose with further exposure, the discrepancy between the initial rate found here and the preferred rates cited in the literature may simply mean that the present experimenter had not given listeners sufficient experience with time-compressed speech, or, alternatively, that previous investigators had not determined preferred listening rates prior to experience. Even so, the initial rate found here was a reproducible phenomenon and the difference between initial and final rates requires explanation. Lass et al. (1974) have demonstrated that lengthy exposure to time-compressed speech will raise the preferred listening rate. Perhaps both the rise after lengthy exposure as well as the rise after the more limited exposure in the present experiment may be due to learning which increases the intelligibility of speech.

An alternative interpretation derives from the statement of Orr (1968) that, although subjects do not dislike listening to compressed speech, there may be an initial negative reaction to it. This suggests that habituation might play a part in the change in preferred rates reported here, in the sense that there may be aversive elements to compressed speech on initial contact which are reduced by repeated or continued exposures.

It is likely that the type of information processing changes after the initial exposure to time-compressed speech. Postman, Thompson, and Gray (1978) have stated that subjects approach an experimental situation with a strong tendency to process words semantically and that a non-semantic task can interfere with this tendency even though it will not completely eliminate it. Upon first exposure to time-compressed speech, considerable phonemic

processing may be required, especially with the higher pitched speeded speech. Phonemic processing may interfere with the more usual mode of semantic processing resulting in low initial rates. During exposure, listeners may be learning to process speech phonemically so that there is less interference with semantic processing following exposure. The relatively smaller gain for speeded speech would be attributed to additional phonemic processing required by increased pitch at higher rates.

In any case, whatever the mechanism of adaptation determined by future research, both the rapid changes seen after the initial exposure to compressed speech, as well as changes after more lengthy exposure reported by Lass and others, suggests that it would behoove investigators in this area to clearly specify the amount of prior exposure to time-compressed speech when reporting preferred listening rates.

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